Productivity of Model EBEYE M for EUVL Mask Inspection

2012 International Symposium on Extreme Ultraviolet Lithography
Monday, 1 October 2012

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Model EBEYE M is EBARA's model code

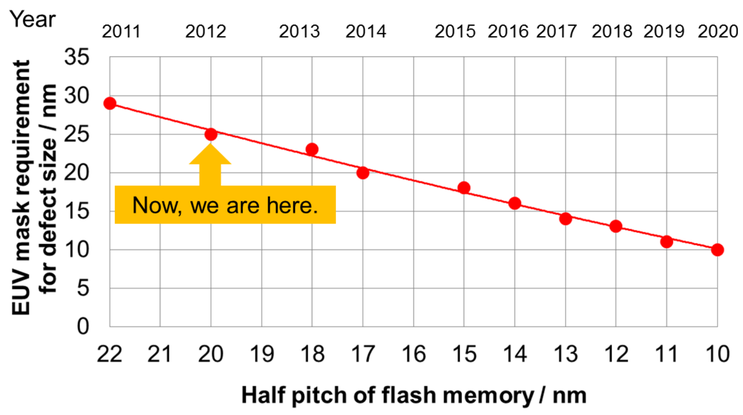
INTRODUCTION

Defect specifications of EUVL mask are more and more severe. EUVL mask inspection must be detected defect size of 20 nm for 2Xnm technology node. We judged that optical inspection with 19Xnm light source and SEM (Scanning Electron Microscope) inspection with EB (Electron Beam) could not have solution to satisfy with both high sensitivity and high throughput by our research. Therefore, new concept inspection tool was needed. The tool is Model EBEYE M having merit of both EB inspection for resolution and optical inspection for throughput. Furthermore, cost of the tool is low, comparing with Actinic inspection.

MOTIVATION

To realize lower cost inspection attaining required sensitivity for production phase of EUVL mask fabrication

EUV MASK REQUIREMENT FOR DEFECT SIZE

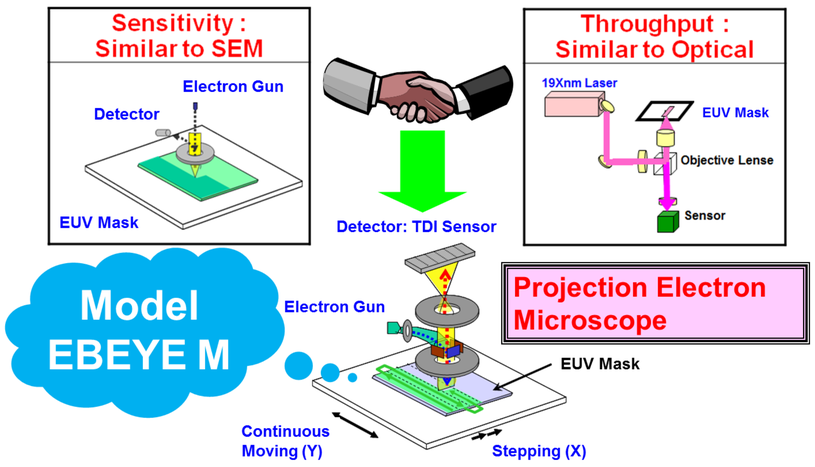


Requirement for defect size of EUV mask

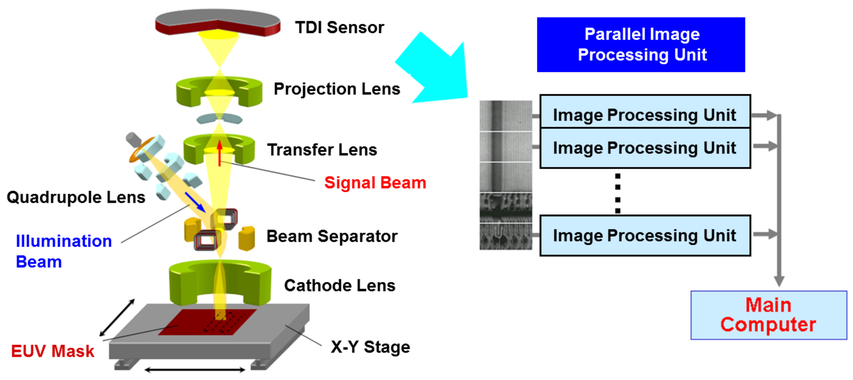
hp 20 nm (Now) ⇒ 25 nm
hp 1X nm (In a few years) ⇒ Under 25 nm

Source ; International Technology Roadmap for Semiconductors 2011 Edition, Lithography, Table LITH6

OUR SOLUTION



FEATURE OF Model EBEYE M



- Projection electron microscope
- Combination of continuous moving stage for Y direction and stepping for X direction
- Inspection images acquired by TDI sensor
- Real time inspection with parallel image processing unit

MILESTONE

Pattern Inspection

Inspection mode : D2D, C2C

Model EBEYE M generation	Phase	Report	Pixel size	Sensitivity	Productivity	Throughput / 100 mm sqr.
Proto-type	Development	2010 BACUS	29 nm	50 nm	-	98 h
For 2X nm	Development	2011 BACUS	20 nm	20 nm	-	13 h
HVM	Production	-	18 nm	18 nm	Capture rate 100 % Repeatability 100 %	10 h

Particle Inspection

Inspection mode : Blank⇒Thr. Pattern⇒D2D, C2C

Model EBEYE M generation	Phase	Report	Pixel size	Sensitivity	Productivity	Throughput / 100 mm sqr.
Proto-type	Development	2010 BACUS	100 nm	30 nm	-	8.2 h
For 2X nm	Development	2011 BACUS	100 nm	20 nm	-	2 h
	Production	-	100 nm	20 nm	Capture rate 100 % Repeatability 100 %	1 h
HVM	Production	-	80 nm	18 nm	Capture rate 100 % Repeatability 100 %	1 h

HVM : 2014/M

CURRENT STATUS OF Model EBEYE M

Pattern Inspection : Under development "HVM" tool
Particle Inspection : Evaluating productivity with "For 2Xnm" tool and under development "HVM" tool

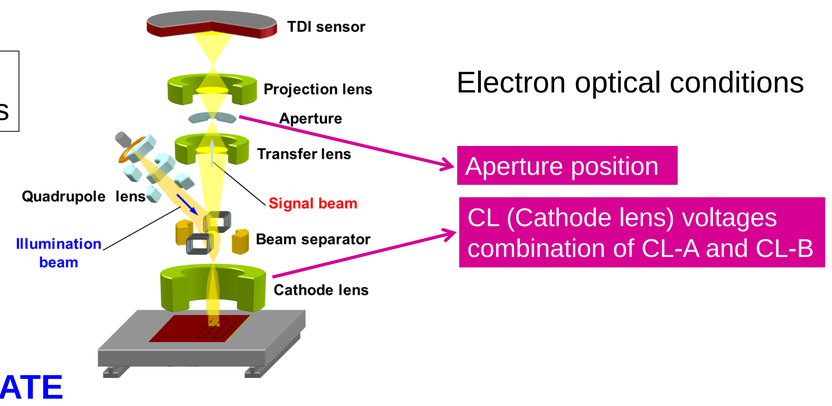
KEY POINT OF THIS REPORT

A) Slightly, moving production phase of mask fabrication with EUV lithography
B) Realization of higher throughput (challenge to lower cost inspection for HVM phase of EUVL mask)

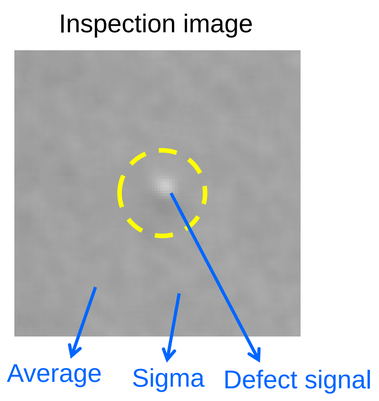
Currently, we progress to evaluate productivity with particle inspection mode of "For 2X nm" tool.
Evaluation items of the productivity is mainly throughput and stability which makes capture rate and repeatability (3runs inspection including load/unload) representation for 20 nm PSL (Polystyrene Latex) on EUVL blank.

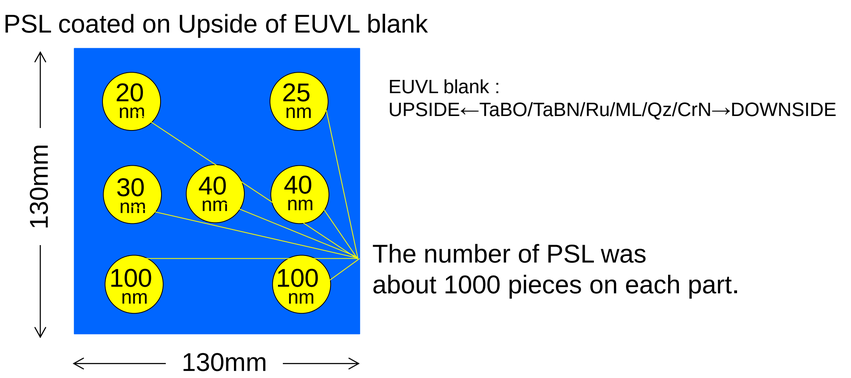
EVALUATION FLOW

The further improvement of SNR by optimization of electron optical conditions
↓
Capture rate evaluation
↓
Repeatability evaluation



DEFINITION OF SNR & CAPTURE RATE



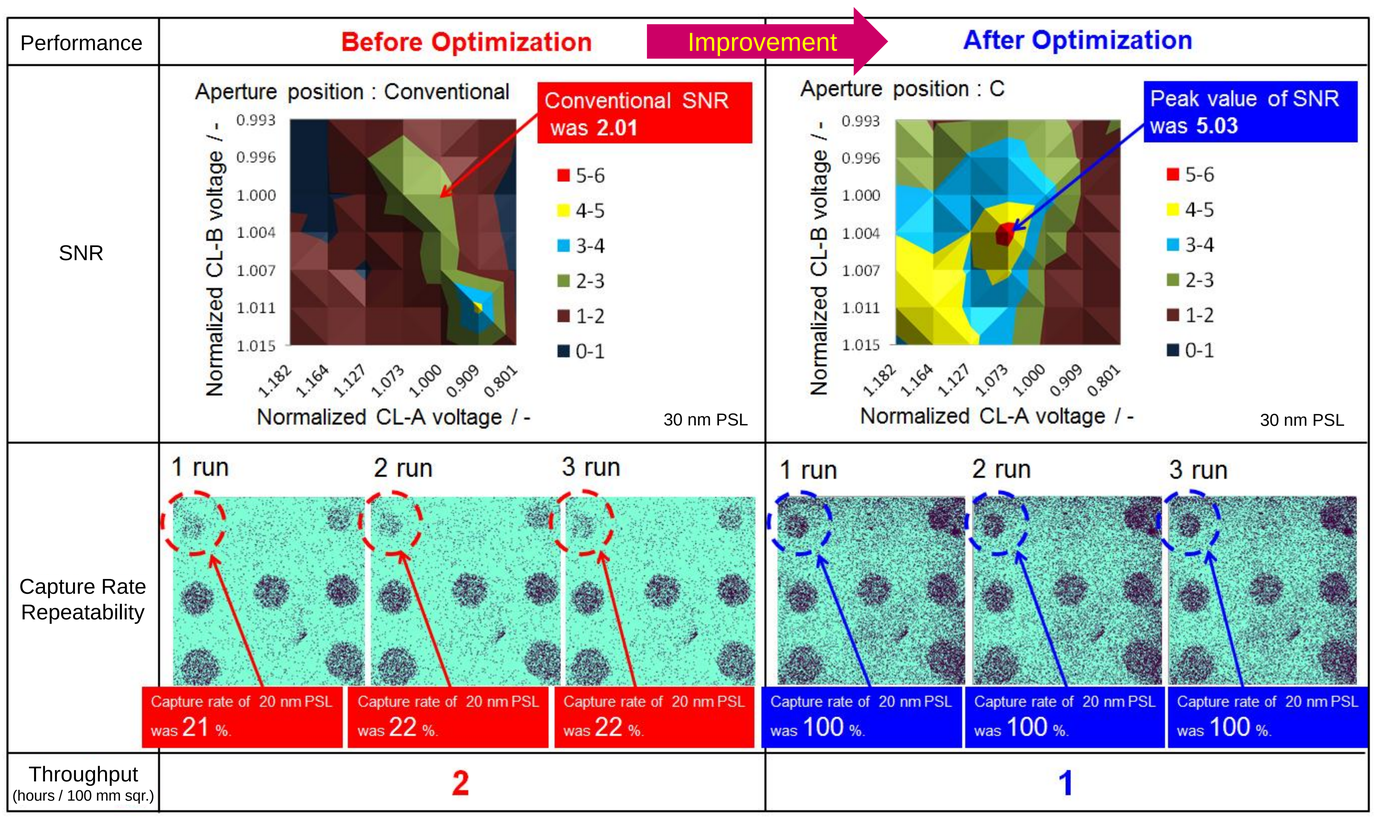


$$\text{SNR} = \frac{|\ \text{Defect signal} - \text{Average}\ |}{\text{Sigma}}$$

$$\text{Capture rate of each size} = \frac{\text{detected defects on each part}}{1000} \times 100\ (\%)$$

The number of

RESULTS



SUMMARY

1) Productivity for particle inspection mode of "For 2X nm" tool was evaluated with PSL on EUVL Blank.
By optimization of electron optical condition,
2) SNR of 30nm PSL was improved 2.5 times.
By improving the SNR,
3) Throughput was improved from 2 to 1 hour / 100 mm square.
4) Capture rate of 20 nm PSL was improved from about 21% to 100%.
5) Repeatability for 3 runs inspection including load / unload was 100%.
We had conclusion that
6) Particle inspection mode in Model EBEYE M "For 2X nm" could be available for EUVL blank inspection of production phase in 2X nm generation.

FUTURE WORKS

1) Evaluation of long term repeatability
2) Risk analysis and (if it has a risk) improvement for Model EBEYE M "HVM" by checking details of data acquired with both particle and pattern inspection mode of Model EBEYE M "For 2X nm"

REFERENCES

(1) "International Technology Roadmap for Semiconductors (ITRS) 2011 Edition, Lithography, Table LITH6"
(2) M. Miyoshi et al, "Electron beam inspection system based on the projection imaging electron microscope", J. Vac. Sci. Technol. B19, 6, 2001, p.2852-2855
(3) Y. Yamazaki et al, "Development of an electron optical system using EB projection optics in reflection mode for EB inspection", Proc. SPIE. 5041, 2003, p.212-219
(4) T. Satake et al, "Electron beam inspection system for semiconductor wafer based on projection electron microscopy", Proc. SPIE. 5375, 2004, p.1125-1134
(5) T. Hirano et al, "Development of EB inspection system EBeyeM for EUV mask", Proc. SPIE. 7823, 2010, 78732C
(6) S. Yamaguchi et al, "Performance of EBeyeM for EUV mask inspection", Proc. SPIE. 8166, 2011, 81662F
(7) M. Naka et al, "Capability of Model EBEYE M for EUV mask production", to be published in the proceedings.

ACKNOWLEDGEMENTS

The authors would like to thank to Mr. Hidekazu Hayashi and Dr. Takashi Kamo of Toshiba corporation, for PSL coating on blank and useful discussion, respectively.